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(54) RAZOR BLADE AND PROCESS FOR FORMING A RAZOR BLADE

RASIERKLINGE UND VERFAHREN ZUR HERSTELLUNG EINER RASIERKLINGE

LAME DE RASOIR ET PROCEDE DE FABRICATION D'UN LAME DE RASOIR

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Description

This invention relates to improved razors and razor blades and to processes for producing razor blades or similar cutting tools with sharp and durable cutting edges. A razor blade typically is formed of a suitable substrate material such as metal or ceramic and an edge is formed with wedge-shape configuration with an ultimate edge or tip that has a radius of less than about 1,000 angstroms. During use, a razor blade is held in the razor at an angle of approximately 25°, and with the wedge-shaped edge in contact with the skin, it is moved over the face so that when the edge encounters a beard hair, it enters and severs it by progressive penetration, aided by a wedging action. It is believed that the cut portion of the hair (which on average is about 100 micrometers in diameter) remains pressed in contact with the blade facets remote from the facial skin surface for a penetration up to only about half the hair diameter. Beyond this, the hair can bend and contract away from the blade to relieve the wedging forces. The resistance to penetration through reaction between hair and blade facets therefore occurs only over about the first sixty micrometers of the blade tip back from the edge and the geometry of the blade tip in this region is regarded as being the most important from the cutting point of view.

It is believed that a reduction in the included angle of the facets would correspondingly reduce the resistance to continued penetration of the blade tip into the hair.

U.S. Patent No. 4,720,918 discloses a razor blade having a steel substrate that has been mechanically abraded to form a wedge-shaped sharpened edge having desirable cutting dimensions.

It has been found, however, when the included angle is reduced too much, the strength of the blade tip is inadequate to withstand the resultant bending forces on the edge during the cutting process and the tip deforms plastically (or fractures in a brittle fashion, dependent on the mechanical properties of the material from which it is made) and so sustains permanent damage, which impairs its subsequent cutting performance, i.e. the edge becomes "blunt" or "dull". As shaving action is severe and blade edge damage frequently results, and to enhance shavability, the use of one or more layers of supplemental coating material has been proposed for shave facilitation, and/or to increase the hardness, strength and/or corrosion resistance of the shaving edge.

U.S. Patent No. 3,761,372 discloses a process for depositing a strengthening layer of metal or alloy material such as chromium or chrome-platinum upon a sharpened edge of a razor blade.

U.S. Patent No. 4,933,058, upon which the preambles of claims 1 and 5 are based, discloses a process for forming hard coatings on razor blades.

A number of coating materials such as polymeric materials, and diamond and diamond-like carbon (DLC) materials have been proposed besides metals and alloys. Diamond and diamond-like carbon (DLC) materials may be characterized as having substantial sp^3 carbon bonding; a mass density greater than 1.5 grams/cm^3; and a Raman peak at about 1331 cm^{-1} (diamond) or about 1550 cm^{-1} (DLC). Each such layer or layers of supplemental material desirably provides characteristics such as improve shavability, improved hardness, edge strength and/or corrosion resistance whole not adversely affecting the geometry and cutting effectiveness of the shaving edge.

German Patent DE 3,047,888 discloses a coated steel substrate having an interlayer of material.

According to a first aspect of the invention, there is provided a process for forming a razor blade including mechanically abrading a substrate to form a wedge-shaped sharpened edge thereon having a tip with a radius of less than twelve hundred angstroms, and forming a layer of diamond or diamond-like carbon material on said sharpened edge of said substrate by positioning said substrate and a solid target member in a chamber, and sputtering said solid target member to generate carbon atoms for forming said layer of diamond or diamond-like carbon material on said sharpened edge of said substrate from said carbon atoms while applying an RF bias to said substrate, said layer of diamond or diamond-like carbon material forming an ultimate tip having an aspect ratio of 1:1 - 3:1, said wedge-shaped sharpened edge being formed with a sharpened tip having an included angle of less than 17° at a distance of 40μm (micrometers) from a tip of said sharpened edge, said layer of diamond or diamond-like carbon material having a thickness of at least 1200 Å (angstroms) from the sharpened tip of the substrate to a distance of forty micrometers from the sharpened tip, characterized in that said ultimate tip has a radius of less than 400 Å (angstroms) and is defined by two facets each having a length of at least about 0.1 micrometer and defining an included angle of at least sixty degrees.

According to a second aspect of the invention, there is provided a razor blade including a substrate having a wedge-shaped sharpened edge formed thereon, said wedge-shaped sharpened edge including a sharpened tip and a layer of diamond or diamond-like carbon material formed on said sharpened edge of said substrate, said layer of diamond or diamond-like carbon material having a thickness of at least twelve hundred angstroms from the sharpened tip to a distance of forty micrometers from the sharpened tip, said layer of diamond or diamond-like carbon material includes an ultimate tip having an aspect ratio ranging from about 1:1-3:1, said sharpened tip having an included angle of less than seventeen degrees at a distance of forty micrometers from the sharpened tip, characterized in that said sharpened tip has an L5 wet wool felt cutter force of less than 0.8 kilogram, dry wool felt (ten cuts) edge damage of less than fifty small edge damage regions and no

damage regions of larger dimension or depth, and a radius at the ultimate tip of less than 400 Å (angstroms), said ultimate tip being defined by facets having a length of at least about 0.1 micrometer and an included angle of at least 60°.

The process may include the step of depositing a layer of material on the wedge-shaped sharpened edge to a thickness of about 300 Å (angstroms) or less prior to depositing the layer of diamond or diamond-like carbon material.

The process may include the step of depositing an adherent polymer coating on the layer of diamond or diamond-like carbon material.

According to another embodiment of the invention, there is provided a shaving unit including a support structure defining spaced-apart, skin-engaging surfaces, one or more razor blade structures mounted to said support structure and being disposed between said skin-engaging surfaces, each said one or more razor blade structure including a razor blade of the type recited above.

The shaving unit may be of the disposable cartridge type adapted for coupling to and uncoupling from a razor handle or may be integral with a handle so that the complete razor is discarded as a unit when the blade or blades become dull. The front and rear skin-engaging surfaces cooperate with the blade edge (or edges) to define the shaving geometry. Particularly preferred shaving units are of the types shown in U.S. Patent 4,586,255.

Other features and advantages of the invention will be seen as the following description of particular embodiments progresses, in conjunction with the drawings, in which:

Fig. 1 is a perspective view of a shaving unit in accordance with the invention;
Fig. 2 is a perspective view of another shaving unit in accordance with the invention;
Fig. 3 is a diagrammatic view illustrating one example of razor blade edge geometry in accordance with the invention;
Fig. 4 is a diagrammatic view of apparatus for the practice of the invention; and
Figs. 5 and 6 are Raman spectra of DLC material deposited with the apparatus of Fig. 4.

Description of Particular Embodiments

With reference to Fig. 1; shaving unit 10 includes structure for attachment to a razor handle, and a platform member 12 molded of high-impact polystyrene that includes structure defining forward, transversely-extending skin engaging surface 14. Mounted on platform member 12 are leading blade 16 having sharpened edge 18 and following blade 20 having sharpened edge 22. Cap member 24 of molded high-impact polystyrene has structure defining skin-engaging surface 26 that is disposed rearwardly of blade edge 22, and affixed to cap member 24 is shaving aid composite 28.

The shaving unit 30 shown in Fig. 2 is of the type shown in Jacobson U.S. Patent 4,586,255 and includes molded body 32 with front portion 34 and rear portion 36. Resiliently secured in body 32 are guard member 38, leading blade unit 40 and trailing blade unit 42. Each blade unit 40, 42 includes a blade member 44 that has a sharpened edge 46. A shaving aid composite 48 is frictionally secured in a recess in rear portion 36.

A diagrammatic view of the edge region of the blades 16, 20 and 44 is shown in Fig. 3. The blade includes stainless steel body portion 50 with a wedge-shaped sharpened edge formed in a sequence of edge forming honing operations that forms a tip portion 52 that has a radius typically less than 500 angstroms with facets 54 and 56 that diverge at an angle of about 13°. Deposited on tip 52 and facets 54, 56 is interlayer 58 of molybdenum that has a thickness of about 300 angstroms. Deposited on molybdenum interlayer 58 is outer layer 60 of diamond-like carbon (DLC) that has a thickness of about 2,000 angstroms, with facets 62, 64 that have lengths of about one-quarter micrometer each and define an included angle of about 80°, facets 62, 64 merging with main facet surfaces 66, 68 that are disposed at an included angle of about 13° and an aspect ratio (the ratio of the distance (a) from DLC tip 70 to stainless steel tip 52 and the width (b) of the DLC coating 60 at tip 52) of about 1.7. Deposited on layer 60 is an adherent telomer layer 72 that has a substantial as deposited thickness but is reduced to monolayer thickness during initial shaving.

Apparatus for processing blades of the type shown in Fig. 3 is diagrammatically illustrated in Fig. 4. That apparatus includes a DC planar magnetron sputtering system manufactured by Vac Tec Systems of Boulder, Colorado that has stainless steel chamber 74 with wall structure 80, door 82 and base structure 84 in which is formed port 86 coupled to a suitable vacuum system (not shown). Mounted in chamber 74 is carousel support 88 with upstanding support member 90 on which is disposed a stack of razor blades 92 with their sharpened edges 94 in alignment and facing outwardly from support 90. Also disposed in chamber 74 are support structure 76 for target member 96 of molybdenum (99.99% pure) and support structure 78 for target member 98 of graphite (99.999% pure). Targets 96 and 98 are vertically disposed plates, each about twelve centimeters wide and about thirty-seven centimeters long. Support structures 76, 78 and 88 are electrically isolated from chamber 74 and electrical connections are provided to connect blade stack 92 to RF power supply 100 through switch 102 and to DC power supply 104 through switch 106; and targets 96 and 98 are connected through switches 108, 110, respectively, to DC magnetron power supply 112. Shutter structures 114 and 116 are disposed adjacent targets 96, 98, respectively, for movement between an open position and a

position obscuring its adjacent target.

Carousel 88 supports the blade stack 92 with the blade edges 94 spaced about seven centimeters from the opposed target plate 96, 98 and is rotatable about a vertical axis between a first position in which blade stack 92 is in opposed alignment with molybdenum target 96 (Fig. 4) and a second position in which blade stack 92 is in opposed alignment with graphite target 98.

In a particular processing sequence, a stack of blades 92 (thirty centimeters high) is secured on support 90 (together with three polished stainless steel blade bodies disposed parallel to the target); chamber 74 is evacuated; the targets 96, 98 are cleaned by DC sputtering for five minutes; switch 102 is then closed and the blades 92 are RF cleaned in an argon environment for three minutes at a pressure of ten millitorr, an argon flow of 200 sccm and a power of 1.5 kilowatts; the argon flow is then reduced to 150 sccm at a pressure of 4.5 millitorr in chamber 74; switch 106 is closed to apply a DC bias of -50 volts on blades 92; switch 108 is closed to sputter target 96 at one kilowatt power; and shutter 114 in front of molybdenum target 96 is opened; for twenty-eight seconds to deposit a molybdenum layer 58 of about 300 angstroms thickness on the blade edges 94. Shutter 114 is then closed, switches 106 and 108 are opened, and carousel 88 is rotated 90° to juxtapose blade stack 92 with graphite target 98. Pressure in chamber 74 is reduced to two millitorr with an argon flow of 150 sccm; switch 110 is closed to sputter graphite target 98 at 500 watts; switch 102 is closed to apply a 13.56 MHz RF bias of one thousand watts (-440 volts DC self bias voltage) on blades 92, and concurrently shutter 116 is opened for twenty minutes to deposit a DLC layer 60 of about two thousand angstroms thickness on molybdenum layer 58. The DLC coating 60 had a radius at tip 70 of about 250 Angstroms that is defined by facets 62, 64 that have an included angle of about 80°, an aspect ratio of about 1.7:1, and a hardness (as measured on the planar surface of an adjacent stainless steel blade body with a Nanoindenter X instrument to a depth of five hundred angstroms) of about seventeen gigapascals (the stainless steel blade body having a hardness of about eight gigapascals). As illustrated in Fig. 5, Raman spectroscopy of the coating material 60 deposited in this process shows a broad Raman peak 120 at about 1400-1500 cm^{-1} wave number, a spectrum typical of DLC structure.

A coating 72 of polytetrafluoroethylene telomer is then applied to the DLC-coated edges of the blades. The process involves heating the blades in a neutral atmosphere of argon and providing on the cutting edges of the blades an adherent and friction-reducing polymer coating of solid PTFE. Coatings 58 and 60 were firmly adherent to the blade body 50 and provided low wet wool felt cutter force (the lowest of the first five cuts with wet wool felt (L5) being about 0.45 kilogram), and withstood repeated applications of wet wool felt cutter forces (the lowest cutter force of the 496-500 cuts being about 0.65 kilogram), indicating that the DLC coating 60 is substantially unaffected by exposure to the severe conditions of this felt cutter test and remains firmly adhered to the blade body 50. Edge damage and delamination after ten cuts with dry wool felt as determined by microscopic assessment was substantially less than commercial chrome-platinum coated blades, there being less than four small edge damage regions (each such small damage region being of less than twenty micrometer dimension and less than ten micrometer depth) and no damage regions of larger dimension or depth. Resulting blade elements 44 were assembled in cartridge units 30 of the type shown in Fig. 2 and shaved with excellent shaving results.

In another particular processing sequence, a stack of blades 92 (thirty centimeters high) is secured on support 90 (together with three polished stainless steel blade bodies disposed parallel to the target); chamber 74 is evacuated; the targets 96, 98 are cleaned by DC sputtering for five minutes; switch 102 is then closed and the blades 92 are RF cleaned in an argon environment for two and a quarter minutes at a pressure of ten millitorr, an argon flow of 200 sccm and a power of 1.5 kilowatts; the argon flow is then reduced to 150 sccm at a pressure of six millitorr in chamber 74; switch 106 is closed to apply a DC bias of -50 volts on blades 92; shutter 114 in front of molybdenum target 96 is opened; and switch 108 is closed to sputter target 96 at one kilowatt power for thirty-two seconds to deposit a molybdenum layer 58 of about 300 angstroms thickness on the blade edges 94. Shutter 114 is then closed, switches 106 and 108 are opened, and carousel 88 is rotated 90° to juxtapose blade stack 92 with graphite target 98. Pressure in chamber 74 is reduced to two millitorr with an argon flow of 150 sccm; switch 110 is closed to sputter graphite target 98 at 500 watts; switch 102 is closed to apply a 13.56 MHz RF bias of 320 watts (-220 volts DC self bias voltage) on blades 92, and concurrently shutter 116 is opened for seven minutes to deposit a DLC layer 60 of about 900 angstroms thickness on molybdenum layer 58. The DLC coating 60 had a tip radius of about 300 Angstroms, an aspect ratio of 1.6:1, and a hardness (as measured on the planar surface of an adjacent stainless steel blade body as measured with a Nanoindenter X instrument) of about thirteen gigapascals.

A coating 72 of polytetrafluoroethylene telomer is then applied to the DLC-coated edges of the blades in accordance with the teaching of U.S. Patent No. 3,518,110. The process involved heating the blades in a neutral atmosphere of argon and providing on the cutting edges of the blades an adherent and friction-reducing polymer coating of solid PTFE. Coatings 58 and 60 were firmly adherent to the blade body 50, provided low wet wool felt cutter force (the lowest of the first five cuts with wet wool felt (L5) being about 0.6 kilogram), and withstood repeated applications of wet wool felt cutter

forces (the lowest cutter force of the 496-500 cuts being about 0.76 kilogram), indicating that the DLC coating 60 is substantially unaffected by exposure to the severe conditions of this felt cutter test and remains firmly adhered to the blade body 50. Edge damage and delamination after ten cuts with dry wool felt as determined by microscopic assessment was substantially less than commercial chrome-platinum coated blades, there being less than four small edge damage regions (each such small damage region being of less than twenty micrometer dimension and less than ten micrometer depth) and no damage regions of larger dimension or depth. Resulting blade elements 44 were assembled in cartridge units 30 of the type shown in Fig. 2 and shaved with excellent shaving results.

In another processing sequence, chamber 74 is evacuated; the targets 96, 98 are cleaned by DC sputtering for five minutes; switch 102 is then closed and the blades 92 are RF cleaned in an argon environment for two and a quarter minutes at a pressure of ten millitorr, an argon flow of 200 sccm and a power of 1.5 kilowatts; the argon flow is then reduced to 150 sccm at a pressure of six millitorr in chamber 74; switch 106 is closed to apply a DC bias of -50 volts on blades 92; shutter 114 in front of molybdenum target 96 is opened; and switch 108 is closed to sputter target 96 at one kilowatt power for thirty-two seconds to deposit a molybdenum layer 58 of about 300 angstroms thickness on the blade edges 94. Shutter 114 is then closed, switches 106 and 108 are opened, and carousel 88 is rotated 90° to juxtapose blade stack 92 with graphite target 98. Pressure in chamber 74 is reduced to two millitorr with an argon flow of 150 sccm; switch 110 is closed to sputter graphite target 98 at 500 watts; switch 102 is closed to apply a 13.56 MHz RF bias of 320 watts (-220 volts DC self bias voltage) on blades 92, and concurrently shutter 116 is opened for five minutes to deposit a DLC layer 60 of about 600 angstroms thickness on molybdenum layer 58. The DLC coating 60 had a tip radius of about 400 Angstroms, an aspect ratio of 1.7:1, and a hardness (as measured on the planar surface of an adjacent stainless steel blade body as measured with a Nanoindenter X instrument) of about thirteen gigapascals. As illustrated in Fig. 6, Raman spectroscopy of the coating material 60 deposited in this process shows a broad Raman peak 122 at about 1543 cm^{-1} wave number, a spectrum typical of DLC structure.

A telomer coating 72 was applied to the blade edges with a nitrogen atmosphere. The resulting coatings 58 and 60 were firmly adherent to the blade body 50, provided low wet wool felt cutter force (the lowest of the first five cuts with wet wool felt (L5) being about 0.6 kilogram), and withstood repeated applications of wet wool felt cutter forces (the lowest cutter force of the 496-500 cuts being about 0.76 kilogram), indicating that the DLC coating 60 is substantially unaffected by exposure to the severe conditions of this felt cutter test and remains firmly adhered to the blade body 50. Edge damage and delamination after ten cuts with dry wool felt as determined by microscopic assessment was substantially less than commercial chrome-platinum coated blades, there being less than five small edge damage regions (each such small damage region being of less than twenty micrometer dimension and less than ten micrometer depth) and no damage regions of larger dimension or depth. Resulting blade elements 44 were assembled in cartridge units 30 of the type shown in Fig. 2 and shaved with excellent shaving results.

While particular embodiments of the invention has been shown and described, various modifications will be apparent to those skilled in the art, and therefore, it is not intended that the invention be limited to the disclosed embodiments, or to details thereof, and departures may be made therefrom within the scope of the invention as defined by the claims.

Claims

1. A process for forming a razor blade (16, 20, 44) including mechanically abrading a substrate (50) to form a wedge-shaped sharpened edge thereon having a tip (52) with a radius of less than twelve hundred angstroms, and forming a layer of diamond or diamond-like carbon material (60) on said sharpened edge of said substrate by positioning said substrate and a solid target member (98) in a chamber (74), and sputtering said solid target member to generate carbon atoms for forming said layer of diamond or diamond-like carbon material (60) on said sharpened edge of said substrate from said carbon atoms while applying an RF bias to said substrate, said layer of diamond or diamond-like carbon material (60) forming an ultimate tip (70) having an aspect ratio of 1:1 - 3:1, said layer of diamond or diamond-like carbon material having a thickness of at least 1200 Å (angstroms) from the sharpened tip of the substrate to a distance of forty micrometers from the sharpened tip, said wedge-shaped sharpened edge being formed with a sharpened tip having an included angle of less than 17° at a distance of 40μm (micrometers) from a tip of said sharpened edge, characterized in that said ultimate tip (70) has a radius of less than 400 Å (angstroms) and is defined by two facets (62, 64) each having a length of at least about 0.1 micrometer and defining an included angle of at least sixty degrees.

2. A process for forming a razor blade according to claim 1, characterized in that said solid target member (98) is a highly pure graphite target, said sputtering step including aligning a shutter (116) between said highly pure graphite target (98) and said substrate in an inert gas environment, applying electrical energy to said highly pure graphite target and opening said shutter (116) for a predetermined period of time while applying said bias to said sub-

strate to form said layer of diamond or diamond-like material.

3. A process for forming a razor blade according to any one of claims 1-2, characterized by the step of depositing an interlayer of molybdenum on said wedge-shaped sharpened edge to a thickness of 300 Å (angstroms) or less prior to depositing said layer of diamond or diamond-like carbon material, said step of depositing said interlayer of molybdenum including positioning a molybdenum target (96) in said chamber (74) and positioning a shutter (114) in alignment between said molybdenum target (96) and said substrate, applying electrical energy to said molybdenum target (96) and opening said shutter (114) for a predetermined period of time to deposit said interlayer of molybdenum.

4. A process for forming a razor blade according to any one of claims 1-3, further including the step of depositing an adherent polymer coating (72) on said layer of diamond or diamond-like carbon material (60).

5. A razor blade (16, 20, 44) including a substrate (50) having a wedge-shaped sharpened edge formed thereon, said wedge-shaped sharpened edge including a sharpened tip (52) and a layer of diamond or diamond-like carbon material (60) formed on said sharpened edge of said substrate, said layer of diamond or diamond-like carbon material (60) having a thickness of at least twelve hundred angstroms from the sharpened tip (52) to a distance of forty micrometers from the sharpened tip (52), said layer of diamond or diamond-like carbon material (60) includes an ultimate tip (70) having an aspect ratio ranging from about 1:1-3:1, said sharpened tip (52) having an included angle of less than seventeen degrees at a distance of forty micrometers from the sharpened tip (52), characterized in that said sharpened tip (52) has an L5 wet wool felt cutter force of less than 0.8 kilogram, dry wool felt (ten cuts) edge damage of less than fifty small edge damage regions and no damage regions of larger dimension or depth, and a radius at the ultimate tip of less than 400 Å (angstroms), said ultimate tip (70) being defined by facets (62, 64) having a length of at least about 0.1 micrometer and an included angle of at least 60°.

6. A razor blade according to claim 5, characterized by an interlayer of molybdenum (58) deposited on said wedge-shaped sharpened edge, said interlayer of molybdenum deposited to a thickness of 300 Å (angstroms) or less, said layer of diamond or diamond-like carbon material (60) being deposited on said molybdenum interlayer (58).

7. A razor blade according to any one of claims 5-6, further including a layer of adherent polymer (72) on said layer of diamond or diamond-like carbon material.

8. A shaving unit (10,30) including a support structure (12, 32) defining spaced-apart, skin-engaging surfaces (14, 26, 34, 36), one or more razor blade structures (40, 42) mounted to said support structure and being disposed between said skin-engaging surfaces, each said one or more razor blade structure (40, 42) including a razor blade (16, 20, 44) according to any one of claims 5-7.

Patentansprüche

1. Verfahren zum Herstellen einer Rasierklinge (16, 20, 44), einschließend mechanisches Abtragen eines Substrats (50), um eine keilförmig geschärfte Kante darauf zu erzeugen, die eine Spitze (52) mit einem Radius von Weniger als zwölf Hundertstel Angström aufweist, und Erzeugen einer Schicht aus Diamant oder diamantähnlichem Kohlenstoffmaterial (60) auf der geschärften Kante des Substrats durch Anordnen des Substrats und eines festen Targetteils (98) in einer Kammer (74) und Sputtern des festen Targetteils, um Kohlenstoffatome zur Bildung der Schicht aus Diamant oder diamantähnlichem Kohlenstoffmaterial (60) auf der geschärften Kante des Substrats aus den Kohlenstoffatomen zu erzeugen, während eine HF-Vorspannung an dem Substrat angelegt wird, wobei diese Schicht aus Diamant oder diamantähnlichem Kohlenstoffmaterial (60) eine äußerste Spitze (70) bildet, die ein Höhe/Breite-Verhältnis von 1:1 bis 3:1 aufweist, wobei die Schicht aus Diamant oder diamantähnlichem Kohlenstoffmaterial eine Dicke von mindestens 1.200 Å (Angström) von der geschärften Spitze des Substrats bis zu einem Abstand von vierzig Mikrometern von der geschärften Spitze aufweist, wobei die keilförmig geschärfte Kante mit einer geschärften Spitze gebildet wird, die einen eingeschlossenen Winkel von weniger als 17 Grad bei einem Abstand von 40 μm (Mikrometer) von einer Spitze der geschärften Kante hat,

dadurch gekennzeichnet, daß die äußerste Spitze (70) einen Radius von weniger als 400 Å (Angström) hat und von zwei Facetten (62, 64) begrenzt ist, die jede eine Länge von mindestens etwa 0,1 Mikrometer haben und einen eingeschlossenen Winkel von mindestens sechzig Grad festlegen.

2. Verfahren zum Herstellen einer Rasierklinge nach Anspruch 1, dadurch gekennzeichnet, daß das feste Targetteil (98) ein hochreines Graphit-Target ist und der Schritt des Sputterns einschließt: achsgerades Einstellen einer Verschlußblende (116)

zwischen dem hochreinen Graphit-Target (98) und dem Substrat in einer Inertgas-Umgebung; Aufbringen von elektrischer Energie auf das hochreine Graphit-Target und Öffnen der Verschlußblende (116) für eine vorbestimmte Zeitdauer, während die Vorspannung an das Substrat angelegt wird, um die Schicht aus Diamant oder diamantähnlichem Material zu erzeugen.

3. Verfahren zum Herstellen einer Rasierklinge nach einem der vorgenannten Ansprüche 1 und 2, gekennzeichnet durch den Schritt des Abscheidens einer Zwischenschicht aus Molybdän auf der keilförmig geschärften Kante bis zu einer Dicke von 300 Å (Angström) oder weniger vor dem Abscheiden der Schicht aus Diamant oder diamantähnlichem Kohlenstoffmaterial, welcher Schritt des Abscheiden der Zwischenschicht aus Molybdän einschließt: Anordnen eines Molybdän-Targets (96) in der Kammer (74) und Anordnen einer Verschlußblende (114) in achsgerader Einstellung zwischen dem Molybdän-Target (96) und dem Substrat; Aufbringen von elektrischer Energie auf das Molybdän-Target (96) und Öffnen der Verschlußblende (114) für eine vorbestimmte Zeitdauer zum Abscheiden der Zwischenschicht aus Molybdän.

4. Verfahren zum Herstellen einer Rasierklinge nach einem der vorgenannten Ansprüche 1 bis 3, ferner einschließend den Schritt des Abscheidens einer haftenden Polymer-Beschichtung (72) auf der Schicht aus Diamant oder diamantähnlichem Kohlenstoffmaterial (60).

5. Rasierklinge (16, 20, 44), einschließend ein Substrat (50), welches darauf eine keilförmig geschärfte Kante aufweist, wobei die keilförmig geschärfte Kante eine geschärfte Spitze (52) und eine Schicht aus Diamant oder diamantähnlichem Kohlenstoffmaterial (60) einschließt, die auf der geschärften Kante des Substrats erzeugt ist, wobei die Schicht aus Diamant oder diamantähnlichem Kohlenstoffmaterial (60) eine Dicke von mindestens 1.200 Å (Angström) von der geschärften Spitze (52) bis zu einem Abstand von vierzig Mikrometern von der geschärften Spitze (52) aufweist, wobei die Schicht aus Diamant oder diamantähnlichem Kohlenstoffmaterial (60) eine äußerste Spitze (70) mit einem Höhe/Breite-Verhältnis im Bereich von 1:1 bis 3:1 einschließt, wobei die geschärfte Spitze (52) einen eingeschlossenen Winkel von weniger als siebzehn Grad bei einem Abstand von vierzig Mikrometern von der geschärften Spitze (52) aufweist,

dadurch gekennzeichnet, daß die geschärfte Spitze (52) eine L5-Naßwollfilz-Schneidkraft von weniger als 0,8 kgf, eine Trockenfilz (zehn Schnitte)-Kantenschädigung von weniger als fünfzig kleinen Kantenschädigungsbereichen mit größerer Abmessung oder Tiefe hat und einen Radius an der äußersten Spitze von weniger als 400 Å (Angström) hat, die äußerste Spitze (70) von Facetten (62, 64) begrenzt ist, die eine Länge von mindestens etwa 0,1 Mikrometer und einen eingeschlossenen Winkel von mindestens 60 Grad haben.

6. Rasierklinge nach Anspruch 5, gekennzeichnet durch eine Zwischenschicht aus Molybdän (58), abgeschieden auf der keilförmig geschärften Kante, welche Zwischenschicht aus Molybdän bis zu einer Dicke von 300 Å (Angström) oder weniger abgeschieden ist, wobei die Schicht aus Diamant oder diamantähnlichem Kohlenstoffmaterial (60) auf dieser Molybdän-Zwischenschicht (58) abgeschieden wird.

7. Rasierklinge nach einem der vorgenannten Ansprüche 5 und 6, ferner einschließend eine Schicht aus haftendem Polymer (72) auf dieser Schicht aus Diamant oder diamantähnlichem Kohlenstoffmaterial.

8. Rasiereinheit (10, 30), einschließend eine Tragkonstruktion (12, 32), die beabstandete, auf die Haut aufsetzende Oberflächen (14, 26, 34, 36) festlegt, eine oder mehrere Rasierklingenkonstruktionen (40, 42), die auf der Tragkonstruktion aufgebaut sind und zwischen den auf die Haut aufsetzenden Oberflächen angeordnet sind, wobei jede der einen oder mehreren Rasierklingenkonstruktionen (40, 42) eine Rasierklinge (16, 20, 40) nach einem der Ansprüche 5 bis 7 einschließt.

Revendications

1. Procédé de formation d'une lame de rasoir (16, 20, 44) comprenant l'abrasion mécanique d'un substrat (50) pour la formation d'un bord aiguisé en forme de coin sur le substrat, ayant un bout (52) dont le rayon est inférieur à 120 nm (1 200 Å), la formation d'une couche de diamant ou d'un matériau de carbone analogue à du diamant (60) sur le bord aiguisé du substrat par positionnement du substrat et d'un organe formant une cible solide (98) dans une chambre (74), et la pulvérisation de l'organe formant une cible solide pour la création d'atomes de carbone destinés à former la couche de diamant ou du matériau de carbone analogue à du diamant (60) sur le bord aiguisé du substrat à partir des atomes de carbone lors de l'application d'une polarisation à haute fréquence au substrat, la couche de diamant ou du matériau de carbone analogue à du diamant (60) formant un bout extrême (70) ayant un rapport d'allongement compris entre 1/1 et 3/1, la couche de diamant ou de matériau de carbone

analogue à du diamant ayant une épaisseur d'au moins 120 nm (1 200 Å) du bout aiguisé du substrat à une distance de 40 µm du bout aiguisé, le bord aiguisé en forme de coin étant formé avec un bout aiguisé ayant un angle inclus inférieur à 17° à une distance de 40 µm du bout du bord aiguisé, caractérisé en ce que le bout extrême (70) a un rayon inférieur à 40 nm (400 Å) et est délimité par deux facettes (62, 64) ayant chacune une longueur d'au moins 0,1 µm environ et délimitant un angle inclus d'au moins 60°.

2. Procédé de formation d'une lame de rasoir selon la revendication 1, caractérisé en ce que l'organe (98) formant la cible solide est une cible de graphite très pur, l'étape de pulvérisation comprenant l'alignement d'un obturateur (116) entre la cible de graphite très pur (98) et le substrat dans un milieu de gaz inerte, l'application d'énergie électrique à la cible de graphite très pur, et l'ouverture de l'obturateur (116) pendant une période prédéterminée avec application de la polarisation au substrat pour la formation de la couche de diamant ou du matériau de carbone analogue à du diamant.

3. Procédé de formation d'une lame de rasoir selon l'une quelconque des revendications 1 et 2, caractérisé par l'étape de dépôt d'une couche intermédiaire de molybdène sur le bord aiguisé en forme de coin avec une épaisseur de 30 nm (300 Å) ou moins avant le dépôt de la couche de diamant ou du matériau de carbone analogue à du diamant, l'étape de dépôt de la couche intermédiaire de molybdène comprenant le positionnement d'une cible (96) de molybdène dans la chambre (74) et le positionnement d'un obturateur (114) dans l'alignement entre la cible de molybdène (96) et le substrat, l'application d'énergie électrique à la cible de molybdène (96), et l'ouverture de l'obturateur (114) pendant une période prédéterminée pour le dépôt de la couche intermédiaire de molybdène.

4. Procédé de formation d'une lame de rasoir selon l'une quelconque des revendications 1 à 3, comprenant en outre l'étape de dépôt d'un revêtement polymère adhérent (72) sur la couche de diamant ou du matériau de carbone analogue à du diamant (60).

5. Lame de rasoir (16, 20, 44) comprenant un substrat (50) ayant un bord aiguisé en forme de coin réalisé sur le substrat, le bord aiguisé en forme de coin comprenant un bout aiguisé (52) et une couche de diamant ou d'un matériau de carbone analogue à du diamant (60) formée sur le bord aiguisé du substrat, la couche de diamant ou du matériau de carbone analogue à du diamant (60) ayant une épaisseur d'au moins 120 nm (1 200 Å) entre le bout aiguisé (52) et un emplacement à une distance de 40 µm du bout aiguisé (52), la couche de diamant ou du matériau de carbone analogue à du diamant (60) comprenant un bout extrême (70) qui a un rapport d'allongement compris entre environ 1/1 et 3/1, le bout aiguisé (52) ayant un angle inclus inférieur à 17° à une distance de 40 µm du bout aiguisé (52), caractérisée en ce que le bout aiguisé (52) a une force d'organe de coupe de feutre de laine humide L5 inférieure à 0,8 kg, une détérioration du bord par un feutre de laine sec (10 coupes) inférieure à cinquante petites régions de détérioration de bord et sans région de détérioration de plus grande dimension ou de plus grande profondeur, et un rayon du bout extrême inférieur à 40 nm (400 Å), le bout extrême (70) étant délimité par des facettes (62, 64) qui ont une longueur d'au moins 0,1 µm environ et un angle inclus d'au moins 60°.

6. Lame de rasoir selon la revendication 5, caractérisée par une couche intermédiaire de molybdène (58) déposée sur le bord aiguisé en forme de coin, la couche intermédiaire de molybdène étant déposée avec une épaisseur de 30 nm (300 Å) ou moins, la couche de diamant ou du matériau de carbone analogue à du diamant (60) étant déposée sur la couche intermédiaire de molybdène (58).

7. Lame de rasoir selon l'une des revendications 5 et 6, comprenant en outre une couche d'un polymère adhérent (72) placé sur la couche de diamant ou du matériau de carbone analogue à du diamant.

8. Unité de rasage (10, 30) comprenant une structure de support (12, 32) délimitant des surfaces espacées (14, 26, 34, 36) de contact avec la peau, et une ou plusieurs structures (40, 42) à lame de rasoir montées sur la structure de support et disposées entre les surfaces de contact avec la peau, chaque structure à lame de rasoir (40, 42) comprenant une lame de rasoir (16, 20, 44) selon l'une quelconque des revendications 5 à 7.

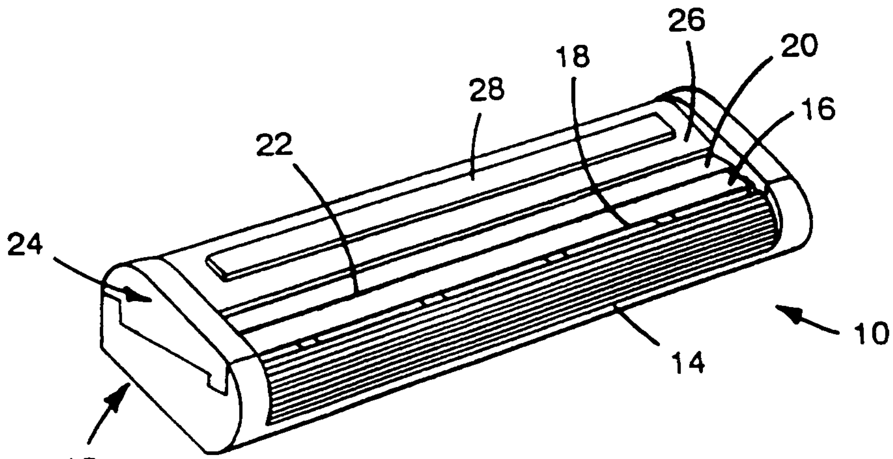

FIG. 1

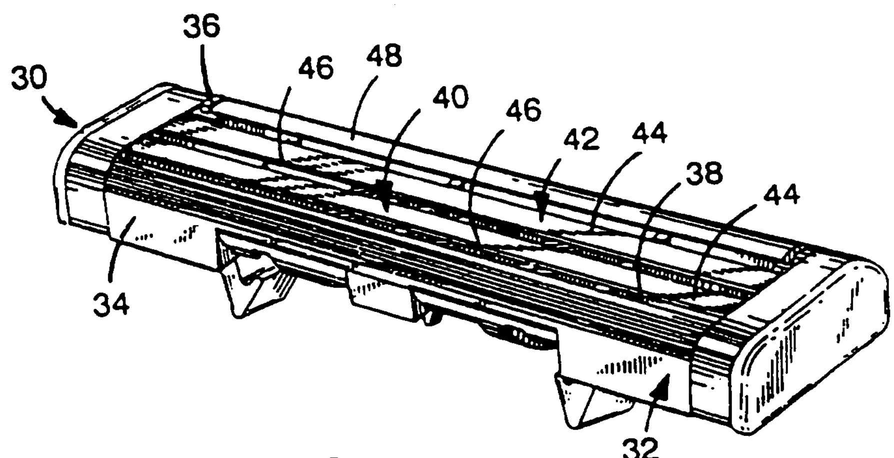

FIG. 2

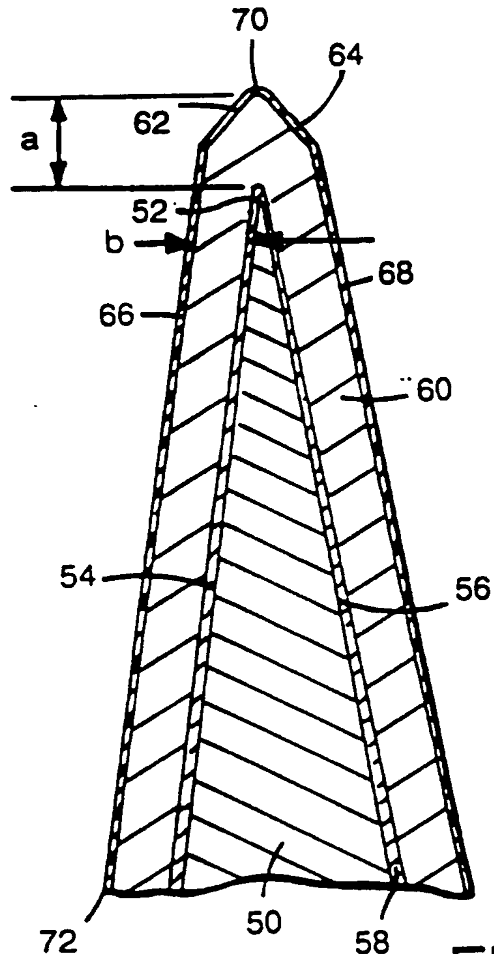
70
64
62
a
52
b
66
68
60
54
56
72
50
58

FIG. 3

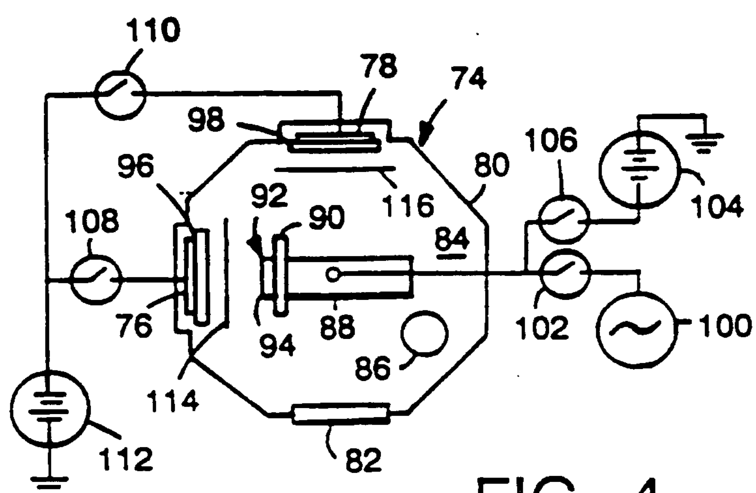
110
78
74
98
96
80
106
104
92
90
116
108
84
76
94
88
102
100
86
114
112
82

FIG. 4

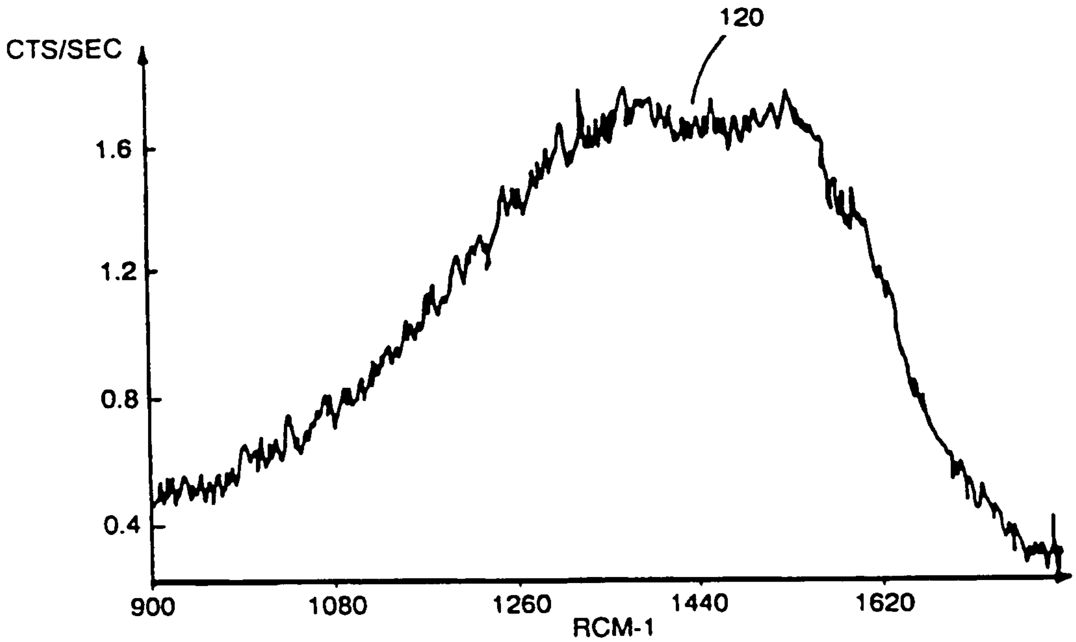
120
CTS/SEC
1.6
1.2
0.8
0.4
900
1080
1260
1440
1620
RCM-1

FIG. 5

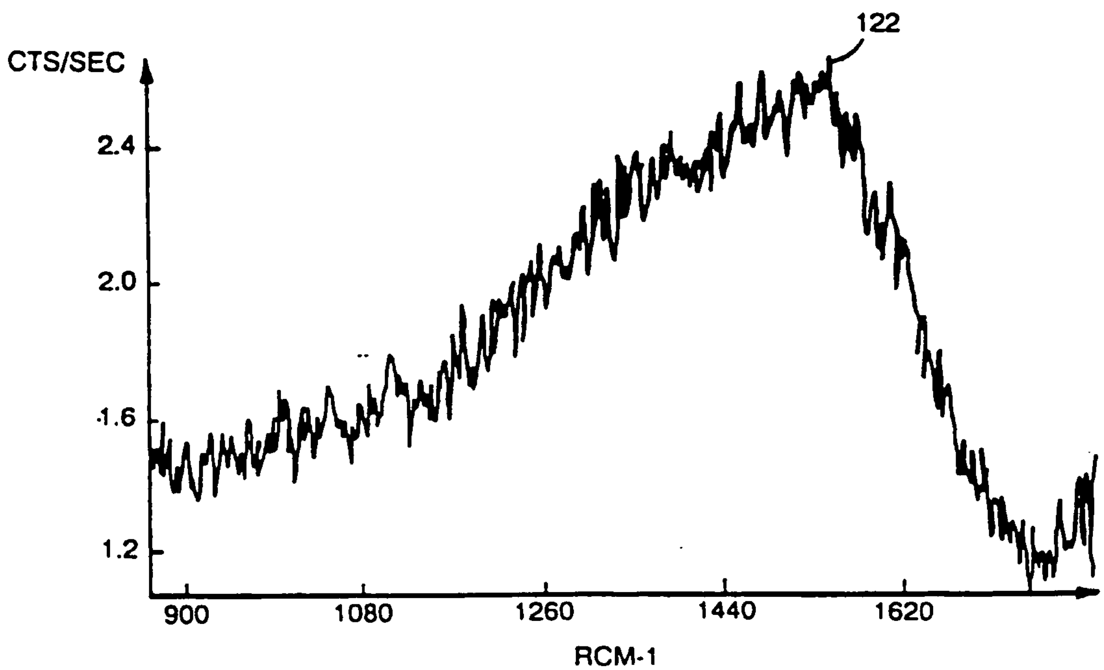
122
CTS/SEC
2.4
2.0
1.6
1.2
900
1080
1260
1440
1620
RCM-1

FIG. 6